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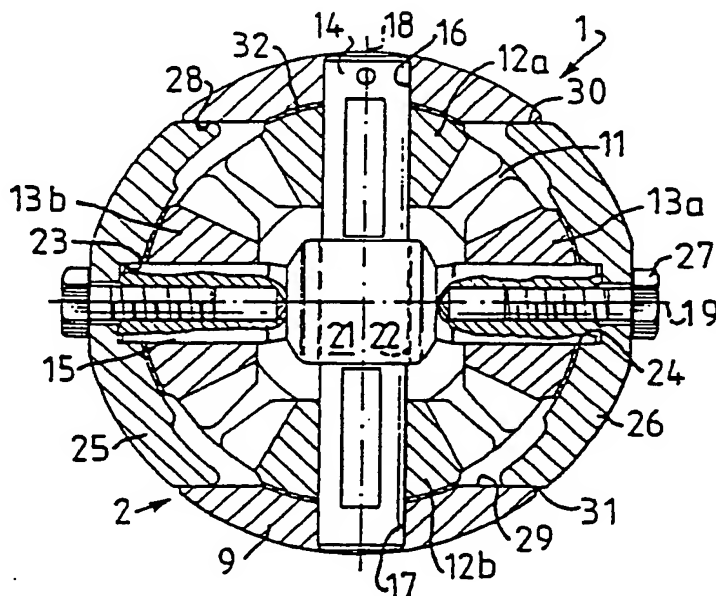
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<p>(21) International Application Number: PCT/SE89/00231 (22) International Filing Date: 26 April 1989 (26.04.89)  (30) Priority data: 8801608-4 28 April 1988 (28.04.88) SE  (71) Applicant (for all designated States except US): SAAB-SCANIA AKTIEBOLAG [SE/SE]; S-151 87 Södertälje (SE).  (72) Inventors; and (75) Inventors/Applicants (for US only) : NORDKVIST, Kjell [SE/SE]; Vasavägen 4, S-151 57 Södertälje (SE). HULT, Lars [SE/SE]; Hallsta, S-646 00 Gnesta (SE).  (74) Agent: HOLMBORN, Erland; Saab-Scania AB, Scaniadivisionen, Utvecklings- och produktionssektorn, Patent, S-151 87 Södertälje (SE).</p>		<p>(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  Published With international search report. In English translation (filed in Swedish).</p>

(54) Title: DIFFERENTIAL WITH FOUR PINION GEARS



(57) Abstract

A differential with a housing (2) made in one piece, which housing has in its wall two large side openings (10), is normally designed with only two pinion gears (12a, 12b) mounted on a pinion gear shaft (14). According to the invention, bearing parts (25, 26) are positioned in the side openings (10) and form the bearing points (23, 24) for a second pinion gear shaft (15) with a further two pinion gears (13a, 13b).

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### Differential with four pinion gears

The invention relates to a differential gearing, especially for motor vehicles, in which a differential housing, made in one piece and provided with a crown wheel, has in its wall, on the one hand, two opposite side openings via which the pinion gears and side gears of the differential can be  
5 introduced into and removed from the differential housing, and, on the other hand, two opposite bearing points situated between the side openings and intended for a first pinion gear shaft provided with two pinion gears, in which respect the axis of the first pinion gear shaft is oriented at right angles to the axis of rotation of the differential housing.

10 Differentials of this type are often used in motor vehicles of the passenger car type, where the torque to be transmitted is fairly small. Designing the differential housing in one piece provides for a compact construction which requires little space and can be produced relatively inexpensively and  
15 simply. However, the disadvantage is that the torque transmission capacity is limited.

When higher torques are to be transmitted, it is possible per se to increase the dimensions of the differential. However, for reasons of space this is  
20 often impossible or undesirable. A commonly used solution is to instead increase the number of pinion gears. Examples of such solutions are described in American Patent Specifications 3,593,959 and 3,974,717. In both cases use is made of four pinion gears which are supported by two pinion gear shafts assembled to form a cross, in which respect the  
25 differential housing is designed in such a way that four bearing points, designed in the form of holes, are accommodated in its wall for the four shaft ends of the cross. This therefore means that a specially designed differential housing has to be used, whose wall is more continuous all round. This reduces the available space for the side openings via which the  
30 side gears and pinion gears can be introduced into and removed from the differential housing, and this makes assembly and disassembly of the differential more difficult.

In order to facilitate the assembly and disassembly of differentials with four  
35 pinion gears, it is also known to design the differential housing in two parts.

in which respect the dividing plane is usually located in the plane in which are situated the pinion gear shafts assembled to form a cross. However, such a construction is more complicated and expensive.

- 5 The aim of the invention is to eliminate the disadvantages of the known differentials and to provide a simple and, thus, inexpensive differential with four pinion gears.

10 According to the invention, this is achieved in a differential of the type mentioned at the outset by virtue of the fact that also included in the differential is a second pinion gear shaft which is provided with two pinion gears and for which the bearing points are arranged in two bearing parts, which are each detachably fixed in the side openings and are guided relative to the differential housing by means of guide members on the latter.

15 According to an advantageous design of such a differential, the guide members of the differential housing are made up of guide surfaces arranged at the edge of the side openings, in which respect the bearing parts are provided with corresponding guide surfaces. It is particularly advantageous in this case for the guide surfaces to have a generatrix parallel to the axis of the second differential gear shaft, and for the guide surfaces of the differential housing to be formed by draw broaching. Such a design has the great advantage that a differential housing of the standard type, intended for two pinion gears, can easily be modified by a simple operation, and, at the same time, necessary extra components are simple to manufacture and to assemble. A further advantage is that the torque transmission capacity is improved without increasing the space requirements.

- 25 30 The invention will be illustrated in greater detail below on the basis of an exemplary embodiment shown in the attached drawing, in which:

Fig. 1 shows a side view of a differential according to the invention, and Fig. 2 shows a section along the line II-II in Fig. 1.

35 A differential 1 according to the invention has a differential housing 2 which is made in one piece and is provided with a round flange 3 on which a

crown wheel 4 is fixed by means of a number of bolts 5. The crown wheel 4 is, in a conventional manner, in engagement with a drive pinion (not shown) mounted on a propeller shaft, by which means the crown wheel 4 can be rotated together with the differential housing 2 around the axis of rotation 6 of the differential housing. Two output shafts 7 and 8 are rotatably mounted in a conventional manner on the differential housing 2 and can therefore be caused to rotate, if appropriate at different speeds.

Given that the general construction of the differential is well known, for example from both American Patent Specifications 3,593,595 and 3,974,717 mentioned in the introduction and also from a number of manuals, the following description deals only with those parts of the differential which are essential for an understanding of the invention.

The differential housing 2 has, in its wall 9, two relatively large, opposite side openings 10, via which components, which are to be accommodated in the differential housing, can be introduced into and removed from the differential housing. This type of differential housing represents a standard type within, for example, the motor car industry.

The output shaft 8 is connected in a conventional manner, fixed in terms of rotation, to a side gear (11) mounted rotatably in the differential housing 2 (see Fig. 2), and the latter is in turn in engagement with four pinion gears 12a, 12b, 13a and 13b, which are rotatably mounted in pairs on a first pinion gear shaft 14 and a second pinion gear shaft 15, respectively. In a corresponding manner, a side gear (not shown), connected fixed in terms of rotation to the output shaft 7, is in engagement with the pinion gears 12a, 12b, 13a and 13b. The first pinion gear shaft 14 is mounted in the differential housing 2 via two bearing points 16 and 17 designed as holes in the wall 9 of the housing. The axis 18 of the first pinion gear shaft 14 forms a right angle to the axis of rotation 6 of the differential housing and also forms a right angle to the axis 19 of the second pinion gear shaft. The first pinion gear shaft 14 is locked in the differential housing 2 by means of a locking device 20 in the form of a pin.

As regards the second pinion gear shaft 15, which has an enlarged central section 21 with a continuous hole 22 for the first pinion gear shaft 14,

bearing points 23 and 24 are arranged in two bearing parts 25 and 26, respectively, which are detachably fixed in each side opening 10. The bearing points 23 and 24 here have the form of blind holes, in which the ends of the second pinion gear shaft 15 touch the bottom. The bearing parts 25 and 26 are each fixed in the axial direction on the second pinion gear shaft 15 by means of a fastening member 27 in the form of a bolt.

At each side opening 10 the differential housing 2 is provided with guide members 28 and 29, which guide the associated bearing part 25 or 26. These guide members are advantageously made up of guide surfaces arranged at the edge of each respective side opening 10, which guide surfaces, in the exemplary embodiment shown, have a generatrix parallel to the axis 19 of the second pinion gear shaft 15 and are expediently produced by means of draw broaching. The bearing parts 25 and 26 are provided with corresponding guide members 30, 31 in the form of guide surfaces.

In the exemplary embodiment shown, at each side opening 10 there are two guide members which are designed as curved surfaces and are situated opposite each other in the circumferential direction of the differential housing. However, it is of course possible to design and position the guide members otherwise, just as it is possible to have another number of guide members. However, the design and positioning shown allows the guide members to be obtained by means of an extremely simple working operation, for example by draw broaching. Moreover, the illustrated positioning of the guide members provides for an advantageous power transmission between the bearing parts and the differential housing.

In order to achieve as even a contour as possible, it is expedient, as shown in the drawing, for the outside of the bearing parts 25, 26 to be situated essentially level with the outside of the differential housing. The second pinion gear shaft 15 is advantageously made in one piece, but it is also possible to divide the shaft up into several parts, for example analogously to what is shown in the two previously mentioned American Patent Specifications 3,593,595 and 3,974,717.

When assembling the differential shown, it is expedient first to assemble the two side gears in the differential housing, after which the pinion gears

12a and 12b are expediently assembled, it being ensured that a liner 32 is put into position as a support for each pinion gear. Thereafter, the two pinion gear shafts 14 and 15 are assembled, then the pinion gears 13a and 13b, and, finally, the two bearing parts 25 and 26, which are thereafter  
5 fixed. Disassembly takes place in the reverse order.

## PATENT CLAIMS

1. Differential, especially for motor vehicles, in which a differential housing (2), made in one piece and provided with a crown wheel, has in its wall (9), on the one hand, two opposite side openings (10) via which the pinion gears and side gears of the differential can be introduced into and removed from the differential housing, and, on the other hand, two opposite bearing points (16, 17) situated between the side openings (10) and intended for a first pinion gear shaft (14) provided with two pinion gears (12a, 12b), in which respect the axis (18) of the first pinion gear shaft (14) is oriented at right angles to the axis of rotation (6) of the differential housing, characterized in that the differential also includes a second pinion gear shaft (15) which is provided with two pinion gears (13a, 13b) and for which the bearing points (23, 24) are arranged in two bearing parts (25, 26), which are each detachably fixed in the side openings and are guided relative to the differential housing by means of guide members (28, 29) on the latter.
2. Differential according to Claim 1, characterized in that the guide members (28, 29) of the differential housing are made up of guide surfaces arranged at the edge of the side openings (10), and in that the bearing parts (25, 26) are provided with corresponding guide surfaces (30, 31).
3. Differential according to Claim 2, characterized in that the guide surfaces (28 - 31) have a generatrix parallel to the axis (19) of the second pinion gear shaft (15), in which respect the guide surfaces (28, 29) of the differential housing are preferably formed by draw broaching.
4. Differential according to Claim 2 or 3, characterized in that at each side opening (10) there are two guide surfaces (28, 29) which are situated opposite each other in the circumferential direction of the differential housing.
5. Differential according to any one of Claims 1 - 4, characterized in that the bearing parts (25, 26) are mounted axially displaceable on the second pinion gear shaft (15).

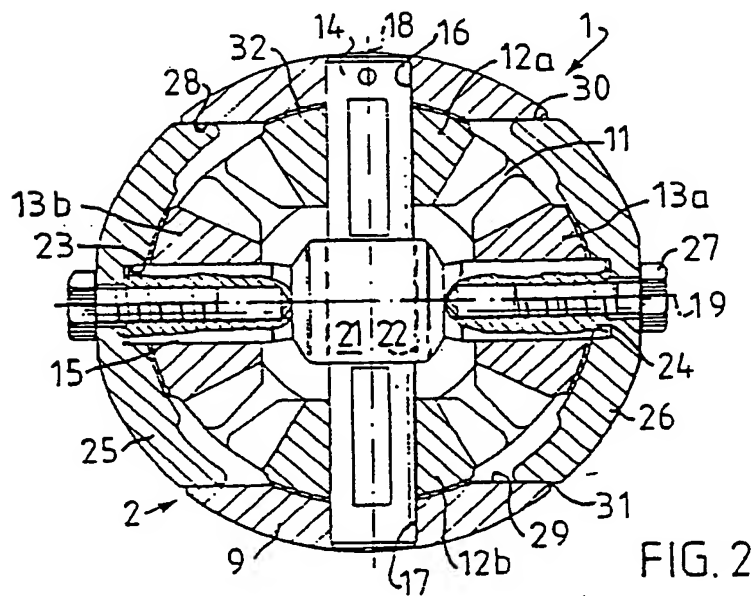
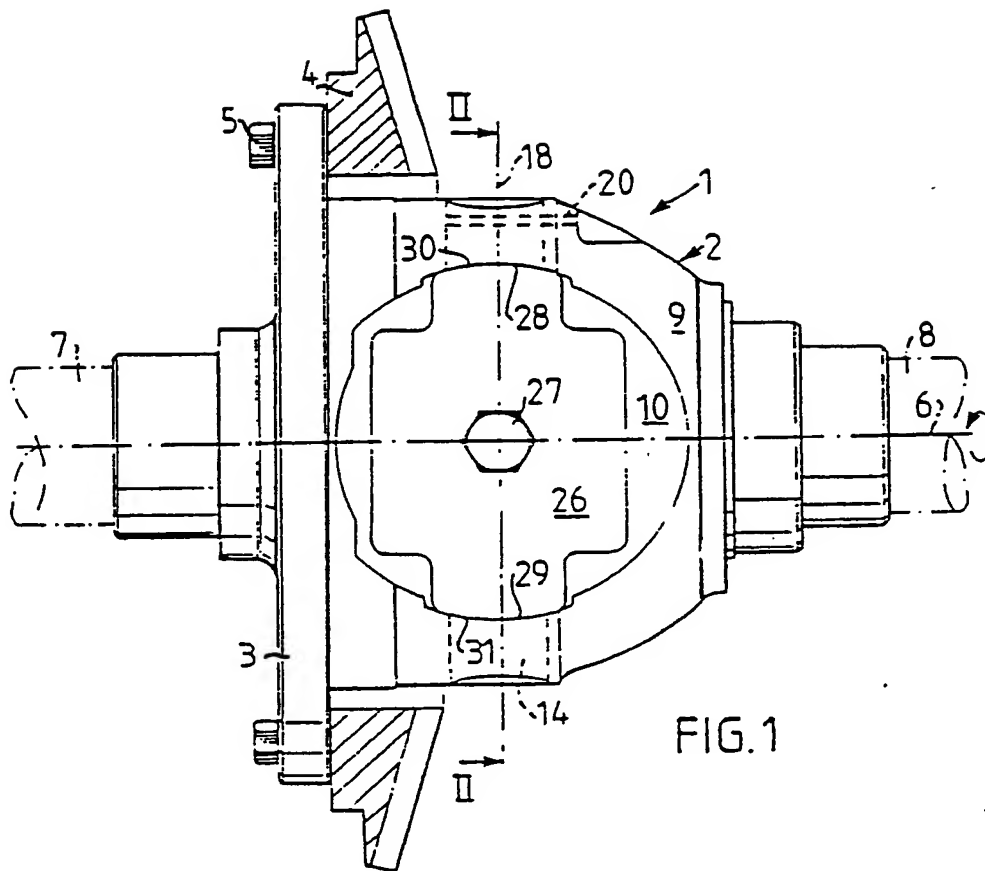


6. Differential according to Claim 5, characterized in that in each bearing part (25, 26) the bearing point (23, 24) for the second pinion gear shaft (15) consists of a blind hole matching its one end at the bearing part, and in that the bearing parts are each connected to the second differential gear shaft via a fastening member (27).  
5

7. Differential according to any one of Claims 1 - 6, characterized in that the second pinion gear shaft (15) has an enlarged central section (21) in which there is a hole (22) for the first pinion gear shaft (14).  
10

8. Differential according to Claim 7, characterized in that the second pinion gear shaft (15) is made in one piece.

9. Differential according to any one of Claims 1 - 8, characterized in that the outside of the bearing parts (25, 26) is located essentially level with the outside of the differential housing (2).  
15



# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE89/00231

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) *	
According to International Patent Classification (IPC) or to both National Classification and IPC 4	
F 16 H 1/40	
<b>II. FIELDS SEARCHED</b>	
Minimum Documentation Searched *	
Classification System	Classification Symbols
IPC 4	F 16 H 1/38, 1/40; B 60 K 17/16
US C1	74:710, 713
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *	
SE, NO, DK, FI classes as above	
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT *</b>	
Category *	Citation of Document, ** with Indication, where appropriate, of the relevant passages **   Relevant to Claim No. **
A	US, A, 4 363 248 (BRISABOIS) 14 December 1982
A	US, A, 3 894 447 (MICHAEL) 15 July 1975
A	US, A, 3 653 280 (KOSKELA) 4 April 1972
A	US, A, 2 566 601 (R. J. W. COUSINS) 4 September 1951
<p>* Special categories of cited documents: **</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>	
<b>IV. CERTIFICATION</b>	
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1989-05-31	1989-06-19
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